Integration of Diesel and Solar Powered Energy Sources to Supply an Off – Grid Residence

MECE 617 Activity

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***Abstract* — this document presents a simple integration of solar energy source and diesel powered generator to provide energy for a single residence which is not connected to the main grid.**

Keywords – Integration, Diesel – Powered Generator, Solar Energy Source

I. INTRODUCTION

A diesel generator is the combination of a diesel engine with an electric generator (often an alternator) to generate electrical energy. This is a specific case of engine-generator. Diesel generating sets are used in places without connection to a power grid, or as emergency power-supply if the grid fails, as well as for more complex applications such as peak-lopping, grid support and export to the power grid. Proper sizing of diesel generators is critical to avoid low-load or a shortage of power [1]. Knowing that diesel is being utilized to power this type of generation, carbon emission is inevitable, that is why incorporating renewable energy source like solar energy to the system can help lessen the emission of carbon to the atmosphere, not to mention the monetary savings we can get out from this initiative especially for a country like the Philippines that has a high cost for diesel fuel and any other products related to diesel.

On the other hand, solar power is the conversion of energy from sunlight into electricity, either directly using photovoltaic (PV), indirectly using concentrated solar power, or a combination. Photovoltaics were initially solely used as a source of electricity for small and medium-sized applications, from the calculator powered by a single solar cell to remote homes powered by an off-grid rooftop PV system. Commercial concentrated solar power plants were first developed in the 1980s. As the cost of solar electricity has fallen, the number of grid-connected solar PV systems has grown into the millions and utility-scale solar power stations with hundreds of megawatts are being built. Solar PV is rapidly becoming an inexpensive, low-carbon technology to harness renewable energy from the Sun [2].

This project will make a simple simulation on the integration of diesel generator and solar photovoltaic in a single residence which is not connected to the grid, solar irradiance data were gathered from the database of NASA (National Aeronautics and Space Administration) available in the web and utilizes the load profile of a particular small residence.

II. METHODOLOGY

A. Design

Design for the off – grid system will consider these varying parameters.

GENERATOR

RATING
150 watts
200 watts
500 watts
750 watts
950 watts

The cost considered for the generator is $136 per 1000 watts rating [4].

PHOTOVOLTAIC PANEL

RATING
100 watts
500 watts
1000 watts

The cost considered for the photovoltaic panels is $1500 per 1000 watts rating [5].

B. Simulation with HOMER

HOMER Energy is the global standard for optimizing microgrid design in all sectors, from village power and island utilities to grid-connected campuses and military bases. Originally developed at the National Renewable Energy Laboratory, and enhanced and distributed by HOMER Energy.

C. Data Gathering

Schedule of Loads

TIME	POWER
00:00-05:00	100 Watts
05:00-07:00	110 Watts
07:00-11:00	220 Watts
11:00-12:00	100 Watts
12:00-15:00	220 Watts
15:00-18:00	100 Watts
18:00-23:00	240 Watts
23:00-00:00	100 Watts

Solar Irradiance

Month	Clearness Index	Daily Radiation (kWh/m2/d)
January	0.501	4.472
February	0.518	4.971
March	0.528	5.413
April	0.553	5.815
May	0.527	5.483
June	0.500	5.121
July	0.493	5.069
August	0.502	5.217
September	0.496	5.096
October	0.511	4.977
November	0.505	4.571
December	0.518	4.495

https://eosweb.larc.nasa.gov/cgi-bin/sse/grid.cgi?email=skip@larc.nasa.gov

III. RESULTS AND DISCUSSION

Simulation in HOMER will give us the following results.

Possible designs for the system are presented below,

Double click on a system below for simulation results.

PV (kW)	GEN1 (kW)	T-105	Conv. (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Diesel (L)	GEN1 (hrs)
0.5	0.20	1	1	$ 1,906	466	$ 7,867	0.426	0.44	331	5,762
0.5	0.20	2	1	$ 2,035	480	$ 8,178	0.443	0.45	302	4,809
0.5	0.15	3	1	$ 2,157	482	$ 8,324	0.451	0.46	287	5,884
0.5	0.20	3	1	$ 2,164	485	$ 8,363	0.453	0.46	290	4,434
0.1	0.20	1	1	$ 1,306	580	$ 8,727	0.472	0.10	473	8,382
1.0	0.20	3	1	$ 2,914	471	$ 8,933	0.484	0.72	204	3,630
0.1	0.20	2	1	$ 1,435	604	$ 9,151	0.495	0.10	473	8,379
1.0	0.50	2	1	$ 2,826	524	$ 9,529	0.516	0.68	285	2,677
1.0	0.50	3	1	$ 2,955	521	$ 9,610	0.520	0.70	245	2,135
0.1	0.20	3	1	$ 1,564	631	$ 9,633	0.521	0.10	473	8,376
0.5	0.50	1	1	$ 1,947	618	$ 9,848	0.533	0.42	444	4,715
1.0	0.50	1	1	$ 2,697	563	$ 9,890	0.535	0.64	373	3,985
0.5	0.50	2	1	$ 2,076	612	$ 9,905	0.536	0.42	403	3,679
0.5	0.50	3	1	$ 2,205	608	$ 9,983	0.540	0.42	370	2,857
1.0	0.75	3	1	$ 2,989	568	$ 10,250	0.555	0.69	290	2,066
1.0	0.75	2	1	$ 2,860	588	$ 10,373	0.561	0.67	344	2,658
1.0	0.95	3	1	$ 3,016	612	$ 10,837	0.586	0.68	332	2,070
0.5	0.75	3	1	$ 2,239	675	$ 10,873	0.588	0.42	429	2,860
0.1	0.50	2	1	$ 1,476	744	$ 10,989	0.595	0.09	563	4,609

With these possible combinations, let us choose the system design that will give us the lowest COE (Cost of Energy), see the image below,

System architecture

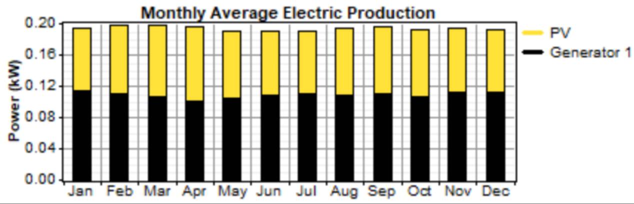
PV Array	0.5 kW
Generator 1	0.2 kW
Battery	1 Trojan T-105
Inverter	1 kW
Rectifier	1 kW
Dispatch strategy	Cycle Charging

Cost summary

Total net present cost	$ 7,867
Levelized cost of energy	$ 0.426/kWh
Operating cost	$ 466/yr

This system design that has the least Cost of Energy utilizes 500 watts Photovoltaic Array, 200 watts Generator powered by diesel, 1 piece Trojan T – 105 deep cycle battery, and 1,000 watts inverter/rectifier as you can see above. The system will cost us $466 per year to operate and $.426 per kWh as the cost of energy.

Component	Production (kWh/yr)	Fraction
PV array	745	44%
Generator 1	955	56%
Total	1,700	100%



We can observe that the cost of energy is a bit higher than our regular energy rate in the Philippines, because as you can see in the image above, 56% of the energy usage comes from the diesel generator, and we should take into consideration that the cost of diesel fuel here in the country is a bit higher, this makes the output of our simulation for this particular design reasonable.

Now, let us take a look at this another design,

System architecture

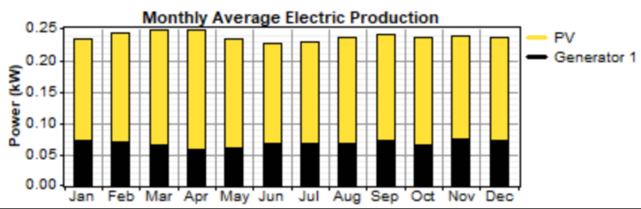
PV Array	1 kW
Generator 1	0.2 kW
Battery	3 Trojan T-105
Inverter	1 kW
Rectifier	1 kW
Dispatch strategy	Cycle Charging

Cost summary

Total net present cost	$ 8,933
Levelized cost of energy	$ 0.484/kWh
Operating cost	$ 471/yr

This system design utilizes 1000 watts PV array, 200 watts diesel generator, 3 Trojan T-105 deep cycle batteries, and 1000 watts inverter/rectifier, costing us $0.484 per kWh, though it has a higher cost of energy than the previous design, taking a look at its performance is perhaps useful for us to choose the right design.

Component	Production (kWh/yr)	Fraction
PV array	1,490	72%
Generator 1	584	28%
Total	2,074	100%



As observed in the image above, for this design, it utilizes more the energy coming from the sun than of the diesel generator, but why does we have a higher cost of energy? Perhaps it is because of the higher capital to put up this kind of design, it will take us a bigger rating of solar PV, and a bunch of batteries. What can we get from this design? Though the price of energy is higher, since this design utilizes more of its energy from renewable source, carbon emission is significantly lower than of the previous design, it may sound noble to consider the carbon emission of the design but it’s a “pick your poison” game right here, it is for us to decide what we think will be favorable for our intent. See the image below for the comparison on their carbon emissions.

DESIGN 1

Emissions

Pollutant	Emissions (kg/yr)
Carbon dioxide	871
Carbon monoxide	2.15
Unburned hydocarbons	0.238
Particulate matter	0.162
Sulfur dioxide	1.75
Nitrogen oxides	19.2

DESIGN 2

Emissions

Pollutant	Emissions (kg/yr)
Carbon dioxide	537
Carbon monoxide	1.33
Unburned hydocarbons	0.147
Particulate matter	0.0999
Sulfur dioxide	1.08
Nitrogen oxides	11.8

V. CONCLUSION

Considering the results presented, the first design that utilizes low cost materials will give us the least cost of energy but will give a significant amount of carbon emissions and the second design is the exact opposite, it will give us a higher cost of energy than the first one but it will deliver less carbon emission.

VI. REFERENCES

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